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Inhalation Technique of 166 Adult Asthmatics Prior to and Following a Self-Management Program

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ABSTRACT

Self-management of asthma and self-treatment of exacerbations are considered important in the treatment of asthma. For successful self-treatment, medication has to be inhaled correctly, but the percentage of patients inhaling effectively

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varies widely. As part of a self-management program we checked and corrected inhalation technique. This paper addresses differences among inhalers in relation to patient characteristics and the effect of instruction, 1 year after enrollment. Maneuvers that are essential for adequate inhalation were identified. When errors in inhalation technique were observed, patients were instructed in the correct use of their devices. One year later, inhalation technique was checked again. Only patients who used the same inhaler throughout the entire study period were analyzed. Of the 245 adult asthmatic patients who were enrolled in the self-management program, 166 used the same inhaler throughout the study period. One hundred twenty patients (72%) performed all key items correctly at baseline and this increased to 80% after 1 year. At follow-up, older patients were less likely to demonstrate a perfect inhalation. Patients with a Diskhaler® made fewest errors. Adjustment for differences in patient characteristics did not significantly change the results. Because many patients with asthma use their inhaler ineffectively, there is a need to know which inhaler leads to fewest errors. Diskhaler was nominated by this study. When patients are not able to demonstrate adequate inhalation technique in a "tranquil" setting, it is doubtful that they can do so when they experience an exacerbation. Therefore, inhalation instruction should be considered an essential ingredient, not only of self-management programs, but also of asthma patient care in general.

INTRODUCTION

In the last two decades asthma self-management training has gained in popularity and at present it is thought to be essential in the treatment of asthma (1,2). One of the important components of self-management is the self-adjustment of the inhaled medication by the patient with changing disease severity, in this paper referred to as self-treatment. Obviously, for self-treatment to be successful, it is imperative that patients use their medication correctly. However, the percentage of patients inhaling effectively varies from 10% to 85% according to the method of assessment of inhalation technique and the type of inhaler investigated (3–8). This clearly demonstrates that checking and improving inhalation technique should be an essential part of asthma treatment in general and of self-management programs in particular, because the efficacy of self-treatment with inhaled medication depends on the ability of the patient to inhale medication adequately.

As part of a self-management program, which included guidelines for self-treatment of exacerbations, we checked inhalation technique in 245 adult outpatients with asthma. If errors were observed, patients were taught the correct inhalation technique. This paper addresses differences in the percentage of patients inhaling correctly, among four types of inhalers most commonly used in our department, in relation to patient characteristics. Furthermore, the effect of instruction 1 year after enrollment in the program was evaluated.

METHODS

Informed consent was obtained from 245 outpatients with asthma, who met our inclusion criteria, e.g., age between 18 and 65 years, moderate to severe asthma, and a minimum daily dose of inhaled steroids of 200 μg beclomethasone, metered-dose inhaler (MDI) equivalent.

The inhalers investigated were MDIs (the "regular" MDI and the Autohaler® [AH], a breath-actuated MDI) and the dry powder inhalers (DPIs): Turbuhaler® (TH), Diskhaler® (DH), Cyclohaler® (CH), Inhaler Ingelheim® (II), and Rotahaler® (RH). AH, CH, and II were used by less than 10 patients and therefore

were not used in the analysis. Eighty-six patients were using more then one inhaler; in these cases the analysis was confined to one device only. The inhaler distribution within the patient sample was not uniform. The DH was used more often than the other inhalers, whereas TH was prescribed relatively seldom. Thus, in order to redress the balance, if patients were using more than one inhaler, a descending order of preference was established as follows: TH, RH, MDI, and DH. Only patients that used the same inhaler throughout the entire study period were analyzed.

Twelve well-trained lung-function technicians, using inhaler-specific checklists adapted from checklists of the Dutch Asthma Foundation (Table 1), assessed inhalation technique, prior to instruction. Every patient was assessed by one lung-function technician only. When errors in inhalation technique were observed, patients were instructed in the correct use of their devices. They received personal instruction from the lung-function technician and were provided with a videotaped instruction, which they took home, together with a copy of their inhaler checklist.

Patient characteristics at baseline are presented in Table 2. Educational achievement was divided into low-, medium-, and high-level education. Patients also answered questions about asthma medication, both prior to and following the self-management program. Answers were converted into a "knowledge score" (0%–100% correct answers).

For each inhaler, items essential for delivery of the active drug into the lungs were identified. When errors are made regarding these key actions, it is likely that no or only an insignificant amount of medicine will be inhaled. These essential maneuvers were different for the four types of inhalers and are indicated in Table 1. Details are described elsewhere (8).

Statistical Analysis

The percentage of patients correctly completing each item on the checklist was calculated for each of the inhalers (Table 1). Further analyses are based on the proportion of patients correctly completing *all essential* inhalation maneuvers on the checklist. Differences among inhaler categories regarding discrete

Table 1. Percentage of Patients Performing the Different Inhalation Maneuvers Correctly, Before and 1 Year After Instruction

	MDI		DISKHALER		ROTAHALER		TURBUHALER	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Shake the inhaler	86[a]	100[a]						
Hold inhaler upright	100	100			71[a]	85[a]	74[a]	69[a]
Insert capsule					95	100		
Hold inhaler horizontal					83	95		
Perforate blister			100[a]	100[a]				
Rotate both ends to open capsule					100[a]	100[a]		
Rotate grip and back until "click"							98[a]	98[a]
Exhale to residual volume	70	84	68	85	49	73	62	79
Exhale away from mouthpiece			90	92	88	90	93	93
Keep head upright or slightly tilted	93	95						
Mouthpiece between teeth and lips	93	95	93	100	95	100	98	95
Inhale slowly and press canister	70[a]	72						
Inhale forcefully and deeply			90[a]	98[a]	90[a]	98[a]	98[a]	98[a]
Continue slow and deep inhalation	91[a]	93[a]						
Hold breath for 5 sec	79	91	83	88	56	76	86	86
Exhale away from mouthpiece			98	100	90	98	98	98
Rotate disk			85	93				

[a]Essential checklist items.

Table 2. Patient Characteristics; Data Are Number of Patients (%) or Mean (SD)

	MDI	DISKHALER	ROTAHALER	TURBUHALER	TOTAL
Number of patients	43 (26%)	40 (24%)	41 (25%)	42 (25%)	166
Mean age	47.0 (11.2)	43.7 (12.6)	45.2 (12.3)	44.5 (12.2)	45.1 (12.0)
Knowledge score, baseline	63.7 (22.9)	60.7 (25.2)	51.1 (21.4)	63.9 (24.7)	59.9 (24.0)
Knowledge score, follow-up	82.6 (20.6)	79.4 (23.1)	76.7 (21.4)	84.4 (15.6)	80.8 (20.3)
Gender					
Male	16 (37%)	23 (58%)	24 (59%)	13 (31%)	76 (58%)
Female	27 (63%)	17 (42%)	17 (41%)	29 (69%)	56 (42%)
Education level					
Low	17 (40%)	15 (38%)	15 (37%)	14 (34%)	61 (37%)
Middle	14 (33%)	14 (35%)	18 (44%)	14 (34%)	60 (36%)
High	12 (28%)	11 (28%)	8 (20%)	12 (32%)	44 (27%)

variables such as gender and educational level were tested using the χ^2-test or Fisher's exact test. Differences in the percentage of patients with a perfect inhalation technique (essential checklist items only) among the four inhalers, adjusted for gender, age, knowledge score, and educational level, were evaluated using logistic regression analyses. Before–after differences in the percentage of patients with a perfect inhalation technique were compared with McNemar's test. Before–after differences in checklist scores were tested by means of the paired *t*-test. The limit of statistical significance was set at $p = 0.05$ (two-sided). Analyses were performed using the statistical package SPSS (9).

RESULTS

Of the 245 adult asthmatic patients who were enrolled in the self-management program, 166 (mean age 45.1 years, mean duration of asthma 20.4 years) were using TH, DH, RH, or regular MDI throughout the study period of 1 year. Table 2 summarizes their characteristics. Individual checklist item scores for the four inhalers are shown in Table 1. Mean overall score for all checklist items, irrespective of type of inhaler prior to instruction, was 85.7%. At follow-up this improved to 91.5%. The difference was statistically significant (95% confidence interval [CI] for difference 2.7–8.0). The most frequent error at baseline was "not exhaling to residual volume," which was done correctly only by 62% of patients. At follow-up this improved to 80%.

One hundred twenty patients (72%) performed all key items correctly at the baseline assessment and this increased to 80% after 1 year. This increase was statistically significant ($p = 0.03$; McNemar test). Multivariate analysis showed that at baseline age, gender, educational level, and baseline knowledge score were not associated with the outcome, whereas after 1 year, older patients were less likely to demonstrate a perfect inhalation, when only essential checklist items were examined.

Both at the initial assessment and at follow-up, differences among inhalers were found. Prior to the educational intervention, 90% of patients with a DH had a perfect inhalation technique, which was substantially higher than the values for the other three inhalers ($p = 0.02$). After 1 year, 98% of patients using the DH made no errors regarding essential checklist items, which was a higher percentage than those using the MDI, RH, and TH ($p = 0.005$).

Adjustment for differences in patient characteristics (multivariate logistic regression with age, gender, educational level, and knowledge score at baseline) did not change the results at baseline, but at follow-up, when knowledge score at follow-up was included in the model, the DH was no longer superior to the RH.

DISCUSSION

It appears that patients enrolled in the self-management program were quite proficient in

the use of their inhaler. They performed more than 85% of all checklist items correctly, which increased to more than 90% 1 year after instruction. However, only 72% of patients succeeded in performing all essential inhalation maneuvers correctly at baseline, which increased to 80% 1 year after instruction. This means that, although instruction is given, in 20% of all patients it is doubtful whether they inhale the correct dose of medication, if they inhale any medication at all. If one or more errors regarding these key actions are made, significant amounts of medication will fail to reach the lungs and as a result, loss of drug efficacy is expected. Note that all patients had to demonstrate adequate inhalation technique following the instruction. Similar results were also observed in another Dutch study including 26 patients with asthma and 24 patients with chronic obstructive pulmonary disease (COPD) (mean age 53.4 years). They found that 2 years after thorough instruction, 27% of all patients showed inadequate inhalation technique (10). Incorrect inhalation of medication was also observed 3 weeks after instruction. In one study, 21% of patients with RH and 8% of those with TH made errors 3 weeks after instruction (11), whereas in another study, 13% still made errors with the MDI (12). Two studies found significantly less bronchodilation in patients who made inhalation errors with an MDI (13,14). Faulty inhalation, therefore, has profound implications for the efficacy of self-treatment in case of an exacerbation. It is also clear that a one-time instruction is not sufficient to ensure adequate inhalation technique, which would argue for repeated checks of inhalation technique at regular intervals.

With respect to the quality of the measurement of inhalation technique, Appel (13) showed that a trained bystander can achieve a 98% success rate in predicting a significant broncholdilator response from the subject's inhalation technique. This supports the validity of our study.

As we have shown, the type of inhaler is related to the ability to inhale the medication correctly. These differences, in favor of the DH, persist even after thorough instruction. It is not easy to compare our results with those of other studies, because the assessment of inhalation technique differs among studies and the inhalers under investigation are not the same. Previously, we assessed inhalation technique in two large groups of patients, using the same checklists for the same inhalers. The first group consisted of 123 patients with COPD, with a mean age of 64 years (7). Prior to instruction, the percentage of patients who performed all essential checklist items correctly was 42%. For MDI, DH, RH, and TH this value was 32%, 86%, 35%, and 46%, respectively. The second group involved 152 patients with COPD with a mean age of 55 (8). In this group, 60% made no errors regarding key inhalation maneuvers. In this study, differences among inhalers were found as well. The percentage of patients performing all essential checklist items correctly was 24%, 96%, 59%, and 61% for MDI, DH, RH, and TH, respectively. The asthmatic patients in the present study, mean age 45 years, with 72% of patients inhaling correctly, compare favorably with both groups of patients with COPD when inhalation technique is considered. The same pattern among inhalers, corrected for differences in patient characteristics, was observed, both before and after instruction, although the MDI seems to be handled relatively better in the present group of patients (see Fig. 1). These three studies from our department would suggest a deteriorating inhalation technique with increasing age, but this conclusion would be premature. Epstein found that, corrected for differences in age distribution, inhalation technique in patients with asthma was better than in patients with COPD (15). In the second group of patients with COPD, we looked for a relationship with age but none was found, although the age range (32–65 years) was somewhat narrow (8). In the present study (age range 18–64 years), older asthmatic patients were less likely to demonstrate a perfect inhalation following instruction. Other authors reported no influence of age (13,15,16). Education might be a confounder, because younger patients are generally better educated, but after correction for differences in educational level the relationship with age persisted. One major point that should not be overlooked is the trend in our department to pay more and more attention to inhalation technique, which has been prompted by the

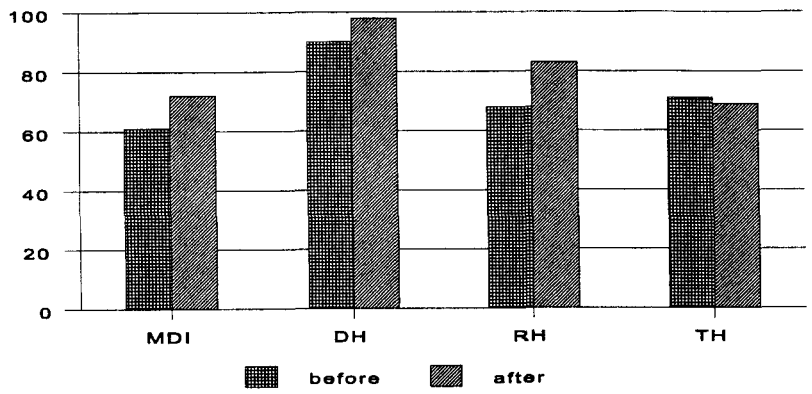

Figure 1. Percentage of patients with a perfect inhalation technique regarding essential checklist items, before and 1 year after instruction. At baseline: Patients with DH more often demonstrated perfect inhalation technique than patients with MDI, RH, or TH (multiple logistic regression, all $p < 0.037$). At follow-up: Patients with DH more often demonstrated perfect inhalation technique than patients with MDI or TH (multiple logistic regression, both $p < 0.012$).

previously mentioned studies (7,8). This fact could possibly explain part of the different results between the various studies, which were done in our department.

We believe that inhaler design factors play a more important role in the success of a given device than the personal characteristics of its user. The superiority of the DH, which was demonstrated in the present study, can be ascribed to the manner by which the powder is released for inhalation. At the baseline assessment, 71% and 74% of patients did not hold the RH and TH vertical (±45°) while inserting the capsule or rotating the grip. This problem with the TH has been reported before (17). One year after a personal and a videotaped instruction, 15% of patients using the RH and 31% of those using a TH still did not keep the devices vertical while loading. This is striking, because it seems to be a relatively simple maneuver. Therefore it seems advisable not only to explain to patients that the RH and TH must be kept vertical when inserting the capsule or twisting the grip, but also to tell them the reason why. For the MDI, the hand–lung coordination is a well-known problem, which exists even after instruction. The DH blister can be perforated with the device in any position, with almost no loss of medicine. This feature might contribute to its superiority in performance over the other devices tested. DH, therefore, seems to be the more foolproof device.

One aspect that should not be overlooked is confounding by indication. This would occur when doctors selectively prescribe certain inhalers to specific types of patients. For example, when patients are considered to have poor dexterity, doctors might not prescribe the DH, because changing the disks, which contain the medicine, might be viewed as problematic. However, this is also true for the RH, with which a small capsule with medication has to be handled. For patients with rheumatic arthritis, firing an MDI or twisting the Turbuhaler grip might also prove difficult. When patients are physically not able to operate their inhaler correctly, this should not be seen as a flaw in the device, but rather as a judgement error by the prescribing physician. Furthermore, because adjustment for differences in age, gender, knowledge, and educational level did not change results much, we think that the problem of confounding by indication is not of sufficient magnitude to explain the observed differences.

One year after instruction, 20% of all patients performed at least one key inhalation maneuver incorrectly, and thus received less then optimal benefit from their therapy. This can have a number of consequences. First, the patient will not inhale enough medicine and thus the therapy will appear to be inadequate. Patients in our study were instructed to double their inhaled steroids for 2 weeks in case of a slow-onset exacerbation. With a faulty inhalation technique, they would not notice any

benefit and would deem their medication useless. Together with the already existing apprehension toward steroids, this could lead to noncompliance. In the event of a fast-onset exacerbation of asthma, inadequate inhalation technique might be life-threatening. Second, there will be a tendency on the part of the clinician to prescribe a higher dose and/or to add other drugs (e.g., prednisolone) to the patient's medication plan, with the concomitant risk of increased side effects and overdosage. Finally, it is possible that the disease is under control but with a dosage of medicines that is far too high because of ineffective inhaler use.

In conclusion, because many patients with asthma use their inhaler ineffectively, there is a need to know which inhaler leads to fewest errors. DH is nominated by this study. When patients are not able to demonstrate adequate inhalation technique in a tranquil setting, it is doubtful that they can do so when they experience an exacerbation. Therefore, inhalation instruction should be considered an essential ingredient, not only of self-management programs, but also of asthma patient care in general.

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